Emission Control for the North Slope

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I'm going to spend just a few minutes talking about air pollution, emission sources, control options, what those emissions result in terms of downwind patterns, and where the Department is heading in terms of air quality management.

These are the contaminants we are interested in, the prime, regulated pollutants we review in the permit process:

- Oxides of Nitrogen – NO_x
- Oxides of Sulfur -- SO_x
- Carbon Monoxide – CO
- Particulate Matter – PM
- Volatile Organic Compounds – VOC

The effects of these contaminants are varied:

- NO_x - Results in a visible plume, and we also have number of health effects; nose and eye irritation, pulmonary edema, bronchitis and pneumonia, ozone precursor, acid rain, vegetation damage.

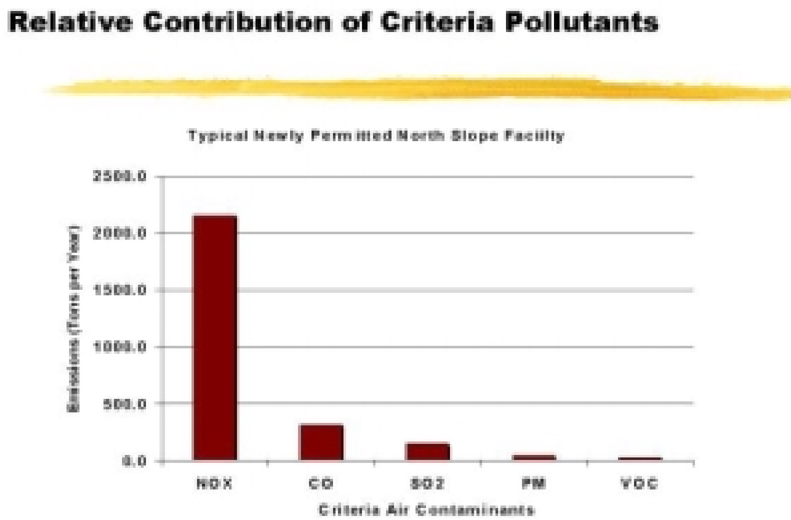
- SO_x - Similar, but the health effects to humans are different. Reduced visibility, breathing difficulty, chronic coughing, acid rain, and can result in significant vegetation damage.

- PM – Is not a contributor to acid rain but it can cause vegetation damage. Reduced visibility, respiratory tract diseases, can vegetation damage.

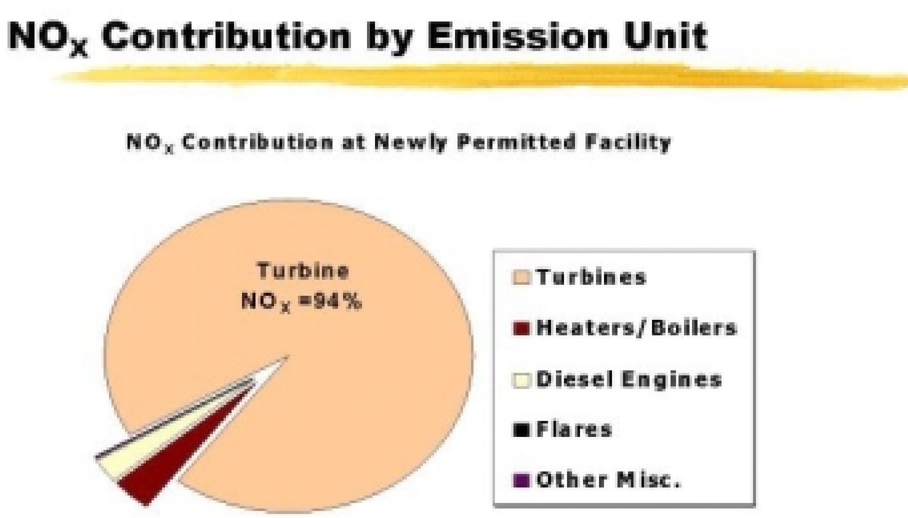
- CO - principally a human health concern, most everybody knows about, automobiles, N slope doesn't really have that problem….reacts with hemoglobin to prevent oxygen transfer; can be fatal.

- VOC – primary pollutant in forming ozone and photochemical smog.

The primary emission units on the North Slope are turbines, heaters and boilers, diesel engines, and flares.



Looking at what we see as relative contributions, the biggest bar on the chart is NO_x emissions. NO_x is formed from nitrogen in the air and the high temperature of combustion.



This graph shows an example of a typical facility, a new installation on the slope, a little over 200,000 tons per year NO_x, emissions, CO in the range of 300 tons per year. SOx is low, and generally is not of concern on the slope because natural gas is the primary fuel, and this has low sulfur content that is partly due to reservoir management by keeping biological activity down to that we aren't having reservoir souring on the Slope.

It's really important to look at where NO_x comes from, for instance the turbines. That's because turbines are the prime mover on the slope, both for electrical power and moving liquids for processing oil and gas. Approximately 94% of the NO_x on the Slope comes from turbine emissions.

This is a typical, single cycle, uncontrolled engine. As a reference point, NO_x emissions are running at about 100 to about 400 PPM NO_x in a standard engine such as this that has been marketed widespread over last decade or so. In this typical North Slope Turbine running at about 15,000 to 50,000 hp in size, and each unit would emits between 200 to 1500 tons per year NO_x. That is our starting point. But I want to remind you of that range but 100 to 400, and we'll look at three different control options: (1) water/steam injection; (2) dry low NO_x control; and (3) selective catalytic reduction. These will give you an idea of what we are seeing in terms of the trends in reducing NOX emissions.

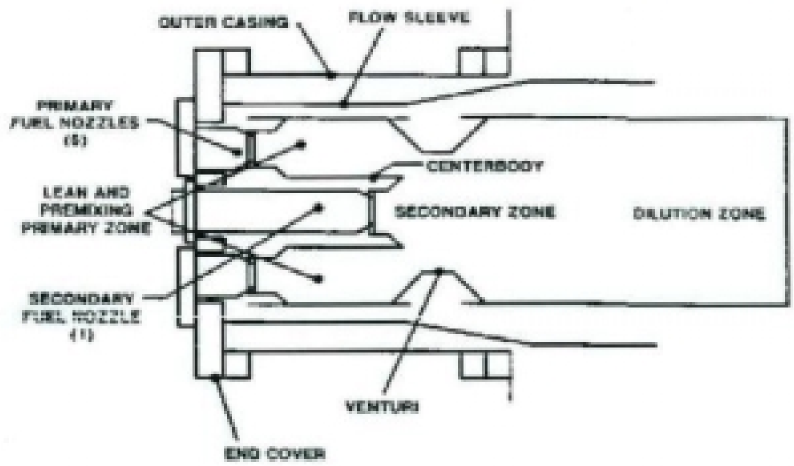
For Water/Steam Injection, the principal is that you are injecting either water or steam into the combustor zone to lower the temperature of combustion and therefore lower NO_x emissions. The benefits of water/steam injection are that we are seeing a 70 – 90% reduction in NO_x up the exhaust stack, so we're getting down to numbers around 25-75 PPM NO_x in the exhaust stacks.

It does have some drawbacks, including high capital costs and operating costs as compared with dry low NO_x. The biggest problem is water. A decade or so ago, when this was basically the only technology available for reducing NO_x emissions on the Slope, water considerations drove industry and government more toward dry low NO_x control because the Slope is arid, and water is not that readily available. Plus, you need to have to have very high purity water (<1 PPM dissolved solids). The process can also increase wear on industrial turbines, and may result in lowered fuel efficiency.

Water/Steam Injection is widely used throughout the U.S., but is not widely used on the Slope. I believe there is one installation on the Slope that is using water injection, at least on a periodic basis.

The next control technology is Dry Low NO_x Control. Here the concept is that you have a lean premix combustor process where air and fuel mix before they enter the combustion chamber to extend the duration of time the combustion occurs

Dry Low NO_x



This diagram shows a schematic of the combustion zone. So, you're trying to keep the temperature down by various design features, hardware features that are built into the engine as you come through the compression zone and into the combustion zone. Lean premix is the most popular dry low NO_x combustor.

Dry Low NO_x

This picture shows some of these combustors that are aligned radially in the engine. We're seeing a 70 to 90 percent reduction in NO_x emission (<10-40 ppm NO_x) through a Dry Low NO_x Control System. Ten to twelve years ago we would see Dry Low NO_x systems that would be about 150 ppm or 170 ppm, and I recently saw a notice out of South Carolina that they are permitting a new turbine that they are putting an emission limit on of 7 ppm for Dry Low NO_x control. It is a proven technology with no water required. The drawbacks are that the costs are higher than conventional combustion system, and that performance may vary with the load on the engine. Dry Low NO_x Control Systems are very widely used in the U.S. and on Alaska's North Slope, and I just want to acknowledge that technology has moved a long way in the last 10 to 15 years.

The newer technology on the horizon is Selective Catalytic Reduction. This also has moved tremendously forward in the last half dozen years. This principal is that ammonia or aqueous urea is injected into the turbine exhaust stream. This is an "add on" control that is installed after the exhaust has gone out of the rear of the engine. This results in the ammonia or urea, aided by a catalyst, to convert the NO_x to atmospheric nitrogen and water.

For the chemistry buffs out there, we have a few equations.

$$4NO_2 + 4NH_3 \text{ --> } 4N_2 + 6H2O$$

$$6NO_2 + 8NH_3 \rightarrow 7N_2 + 12H_2O$$

We are seeing greater than 90% NO_x control, down to two ppm, and it works well in tandem with these other technologies, such as the Dry Low NO_x design combustor unit coupled with an add-on technology in the exhaust stack. The disadvantages are that the capital cost is very high, and the operating costs are something to be concerned about too. We also have another issue now as we add ammonia to the equation. We have some "slip" of ammonia out of the exhaust, and that can be of concern. Manufacturers generally specify less than 10 ppm ammonia slip from the exhaust. SCR may also have some water requirements. Right now we are seeing over 100 installations across the U.S. since 1986. California is actually requiring as low as 3 ppm permitted for NO_x for SCR. We have not seen any SCR equipped turbines in Alaska.

That is a snap shot of those three technologies for NO_x control.

I want to make a few points about vegetation affects because you are really protecting health at the ground level, protecting vegetation or other habitat, or you may be interested in long-range transport of air pollutants, such as acid rain.

Not too long ago, between 1989-1994, there was a 5 year study looked at vegetation- funded by AOGA and the ASTF looking at what, if any, changes were occurring in the vegetation immediately downwind from the largest sources on the slope. So this looked at the Central Compressor Plant compressors, which would have been the largest sources on the Slope. They looked at three aspects, and I am not a vegetation biologist, so I don't know the details, but they looked at plant diversity – what the plant community was, foliar injury and physiology. Sometimes you will have an effect where one plant species may die out because it can't tolerate the pollution, while others thrive, so you will see a change in the composition, or a change in diversity. You can also see direct impacts to the foliage as spotting or burning edges of the leaves, and so on. And then we looked at the physiology in terms of the nitrogen uptake, and what impacts the NO_x had on the plant.

So those are the three aspects that were looked at. As for results, there were no observed damages during that five-year period. However, there is some caution in that the study needs periodic re-look for long term, so it needs to be revisited. There was one part of the report that indicated that for at least one of the species there was a higher N uptake by one of the plants closer to the facility, but in a lab situation, it didn't show it. So it left a question. Some of us that have been around the field for awhile know that if you go to certain areas near big smelting operations, you can visibly see where the vegetation has died off for 20 miles around the facility.

In managed air quality we try to control pollutants to "prevent significant deterioration", so you have a cap on pollution growth at the ground level, that is actually in this case for NO_x, is one quarter of the public health standard. So we are operating at a low benchmark, and that benchmark is meant to be protective of pollution growth.

So, I have a few conclusions. Again, to reiterate what you heard earlier this morning, the Department and Industry must continue too work together, and with the public as well, in a partnership to ensure and maintain clean air on the North Slope of Alaska. We have three proven technologies that are each effective in reducing NO_x emissions: Water/Steam Injection, Dry Low NO_x, and Selective Catalytic Reduction. The SCR is a technology that needs a closer look in the future.

We do not think of air quality as one of the front and center bright line environmental controversial issues for the North Slope. But I would like to leave you with the fact that it is very much an important issue. When folks talk about enhanced development they talk about the air pollution emissions. And I think it is important for all of us to remember that we do need to move forward on reducing emissions. Even though we meet public health standards with best available control technologies, and we push the Clean Air Act, we need to continue to develop these technologies.

With that, I'll say "thank you".